NOTES AND CORRESPONDENCE

Radar Wind Profiler Observations of Fronts and Jet Streams

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30 January 1984 and 9 April 1984

1. Introduction

Recent technological advances in UHF–VHF radar wind profiling represent a major breakthrough in obtaining accurate, low-cost, temporally continuous, high vertical resolution wind profiles. Whereas many past reports (e.g., Gage and Balsley, 1978; Gage and Clark, 1978; Green and Van Zandt, 1978; Larsen and Röttger, 1982; Röttger, 1980; Strauch *et al.* 1983) have focused upon instrument design, performance characteristics and meteorological observations from a single site, the present note presents mesoscale meteorological analyses derived from a network using this new observing technology. Examples depicting a surface front, an upper-level front and its associated jet streak serve to illustrate the potential application of wind profiler networks for describing and forecasting the spatial and temporal evolution of synoptic and mesoscale wind regimes.

2. The NOAA wind profiler network

The NOAA Wave Propagation Laboratory maintains a network of one UHF and four VHF profilers. The UHF system is located at Stapleton International Airport, Denver, Colorado; the VHF systems are at Platteville, Cahone, Lay Creek and Fleming, Colorado (see Fig. 1). (The Platteville VHF system, operated jointly with the NOAA Aeronomy Laboratory, is an outdated design and it gives wind fields with only 1.5 km vertical resolution; and for this reason, it was not incorporated into the analyses that follow.) All profilers are programmed for one profile per hour (an average of 12 individual profiles within the hour), with varying vertical resolution. The UHF system has 100 m resolution from 0.3 km above ground level (AGL) to ~2.6 km, 300 m resolution from 1.6 to ~8.3 km AGL and 900 m resolution between 2.7 and ~14.0 km AGL. The outlying VHF systems provide wind data with 300 m resolution from 1.7 to 8.4 km AGL and 900 m resolution between 2.6 and 17.4 km AGL. Changes in vertical resolution are accomplished by changing the pulse length of the radar.

3. The upper-level front and jet stream of 13–14 June 1983

During 13–14 June 1983, an unusually strong (for the time of year) trough containing upper-level frontal and jet streak structure passed over the Colorado profiler network. The 1200 GMT 13 June 300 mb wind analysis (Fig. 2) based upon rawinsonde and profiler data shows the 50 m s^{-1} jet streak entering southwestern Colorado. The Cahone profiler provided a key observation for this analysis, by measuring the 55 m s^{-1} wind speed over the southwest corner of Colorado.

The time series analysis of the Cahone hourly wind

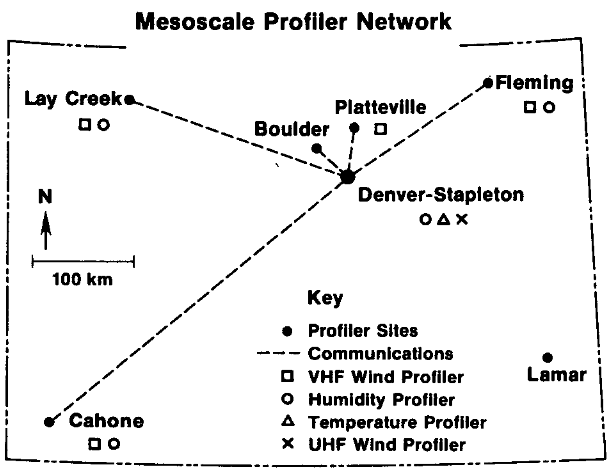

FIG. 1. Colorado Profiler Network.

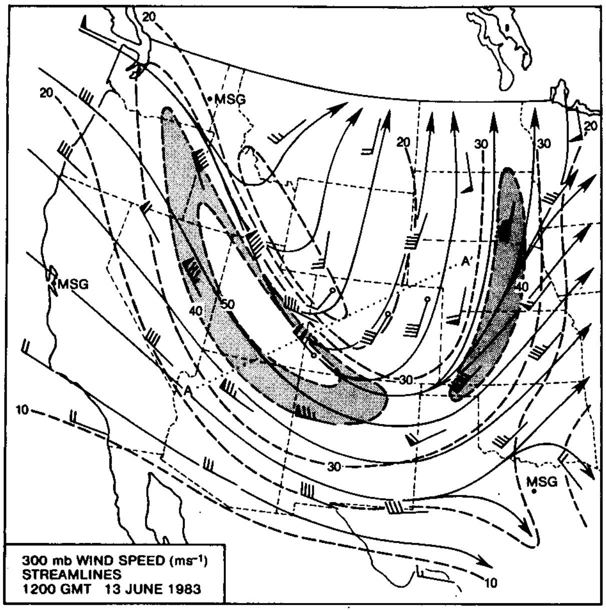

FIG. 2. 300 mb wind velocity analysis at 1200 GMT 13 June 1983. Profiler wind vectors, open circles; wind speed (m s^{-1}), dashed lines; streamlines, thin lines; flag = 25 m s^{-1}, full barb = 5 m s^{-1}, half barb = 2.5 m s^{-1}.

profiles (Fig. 3) shows the temporal continuity of the jet-level ($\sim$300 mb) winds and the associated frontal vertical wind shear below the jet between 1300 and 2000 GMT. Note that the 300 m vertical resolution gives adequate definition to the $\sim$1 km thick middle-tropospheric wind shear layer beneath the jet.

Figure 4 presents the cross-sectional analysis of wind speed and potential temperature along the line AA′ of Fig. 2 prepared from a composite of conventional rawinsondes and four radar wind profilers. In the analysis, the Cahone profile intercepted the upper-level and jet streak core between the Winslow, Arizona (INW) and Grand Junction, Colorado (GJT), balloon sounding sites. The wind profiles from Lay Creek, Fleming and Stapleton, and the Denver (DEN) raob documented the weak wind speeds near the trough axis (Fig. 2) and the 20 m^{-1} southwesterly flow in advance of the trough near 300 mb.

After 1200 GMT 13 June, the trough and jet streak (Fig. 2) and front (Fig. 4) continued eastward and passed over the Lay Creek profiler. The hourly sequence from Lay Creek (Fig. 5) shows the appearance

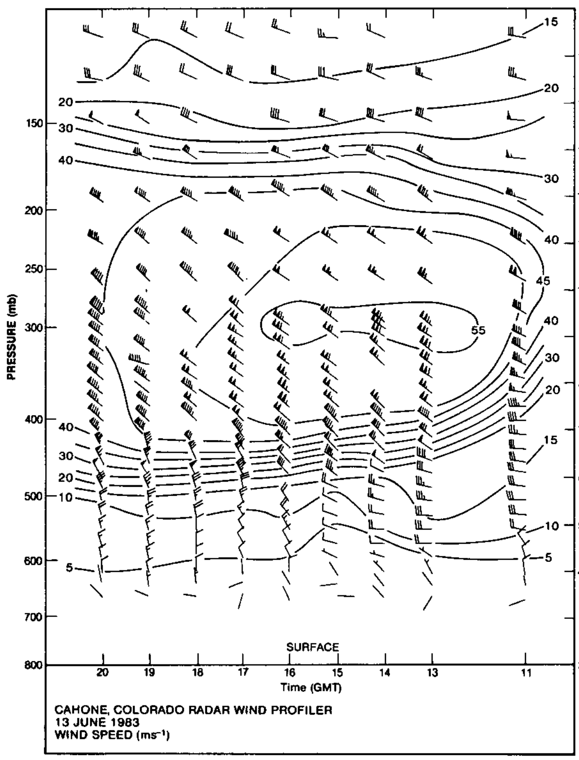

FIG. 3. Time series analysis of wind speed (m s^{-1}) and wind vector plot for the Cahone, Colorado, VHF radar wind profiles between 1100 and 2000 GMT 13 June 1983. Flags and barbs are the same as those in Fig. 2.

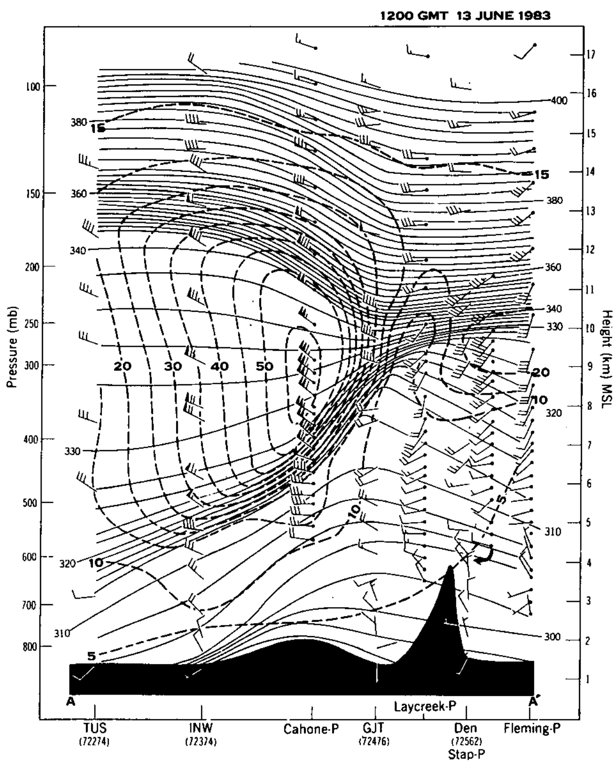

FIG. 4. Cross-sectional analysis of wind speed (m s^{-1}, dashed lines) and potential temperature (K, solid lines) at 1200 GMT 13 June 1983 along the projection line AA′ of Fig. 2. Analysis is a composite of conventional rawinsonde soundings and radar wind profiles. Profiler soundings are designated by the letter P at the horizontal axis. Flags and barbs are the same as those in Fig. 2.

(after 2100 GMT) of the frontal shear layer and its intensification and descent from 9.2 to 6 km by 1000 GMT. The jet core passed overhead at 0300 GMT. Fig. 5 was space–time adjusted so that the time axis was proportional to the horizontal structure of the jet-front system, assuming no change in structure during the time of passage over the profiler. For the present case, the group velocity of the trough and embedded jet-front was 18 m s^{-1}, giving a time-to-distance conversion of 1 h = 66 km. After adjusting to a distance axis comparable with that in Fig. 4, we note the striking similarity between the spatial structure of the composite cross section (Fig. 4) and the adjusted time series (Fig. 6).

4. The surface frontal passage on 12 June 1983

On the day before passage of the upper-level front, a low-level (surface) front passed over the Rocky Mountains and was observed with the high-vertical-resolution Stapleton UHF profiler. The time series analysis of the 100 m vertical resolution wind profiles (Fig. 7) contains 2 h resolution because computer failure did not permit the usual 1 h data archiving. The analysis shows weak easterly flow below 3 km before 0000 GMT 12 June. By 0400 GMT, this flow became southerly and increased in speed just before frontal passage. The Stapleton surface winds documented frontal passage at ~0420 GMT. A low-level southerly wind speed maximum appeared above the leading edge of the front between 0400 and 0600 GMT. After 0600 GMT, the winds beneath the frontal layer were northerly to northeasterly, becoming easterly up to 2.8 km by 1800 GMT.

5. Summary

The case study analyses illustrate the ability of VHF and UHF wind profilers to document the vertical, horizontal and near-continuous temporal structure of frontal and jet streak mesoscale wind flows. It remains for future construction of continental profiler networks with spatial separation of 300 km to facilitate the monitoring of upper- and lower-tropospheric wind systems and fronts with temporal continuity comparable with that of present satellite and weather radar observing systems. When compared with the present two soundings per day of operational rawinsondes, the profilers

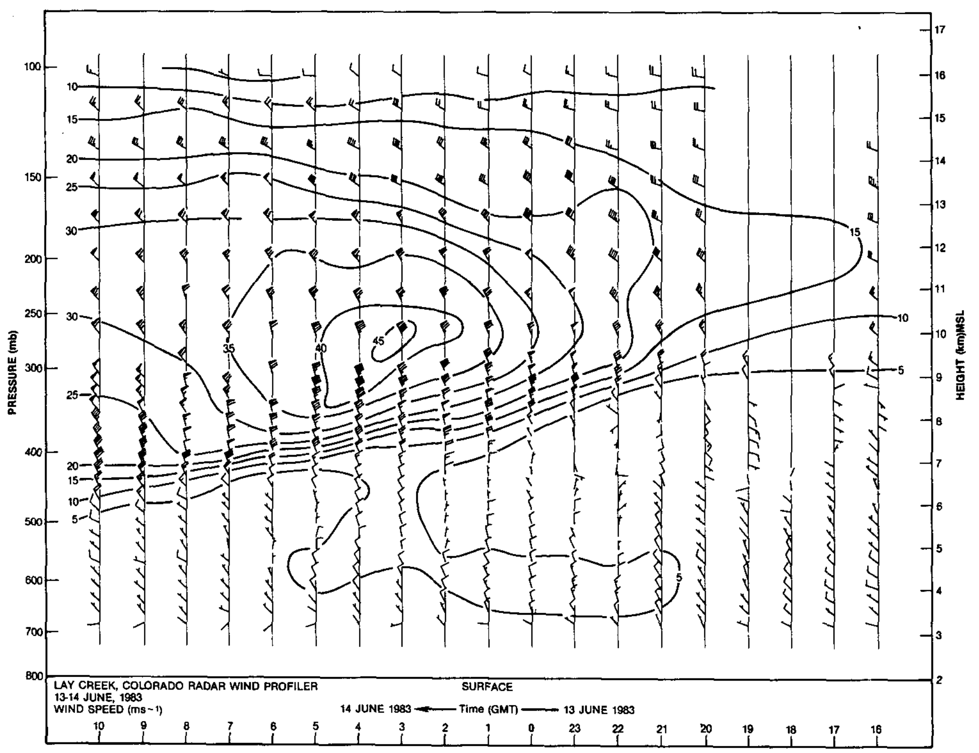

FIG. 5. Time series analysis of wind speed (m s^{-1}) and wind vector plot for the Lay Creek, Colorado, VHF radar wind profiler between 1600 GMT 13 June and 1000 GMT 14 June 1983. Flags and barbs are the same as those in Fig. 2.

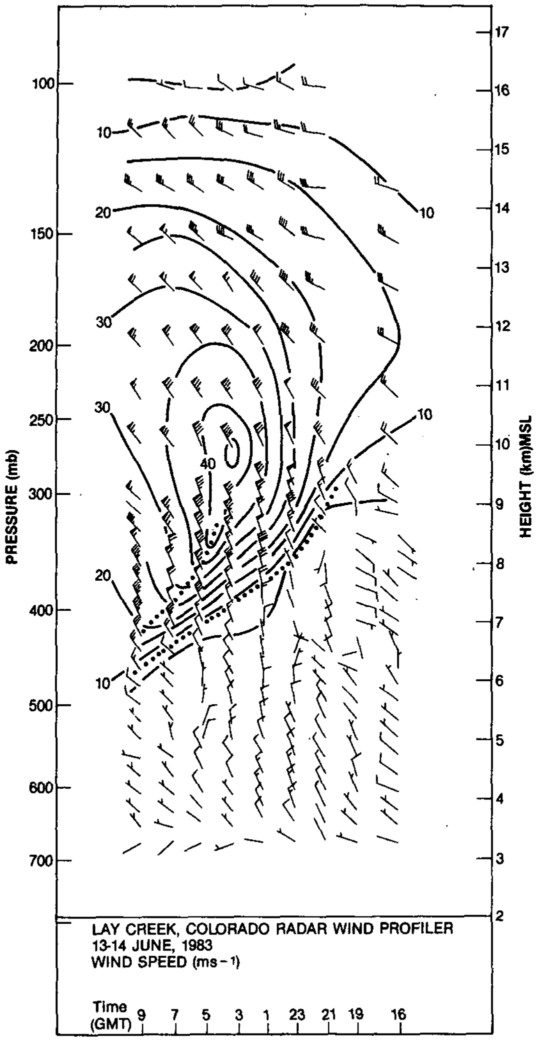

FIG. 6. Time-to-space adjusted version of Fig. 5 with an equivalent horizontal distance scale to Fig. 4. Wind vector plots are the same as those in Fig. 5, for the times indicated (every other hour). Dots are frontal boundary zones.

represent a major advance toward obtaining the wind observations required to improve the depiction, physical process diagnosis, short-term (≤6 h) prediction (statistical and extrapolation) and numerical prediction (≥6 h) of synoptic-scale and mesoscale weather events.

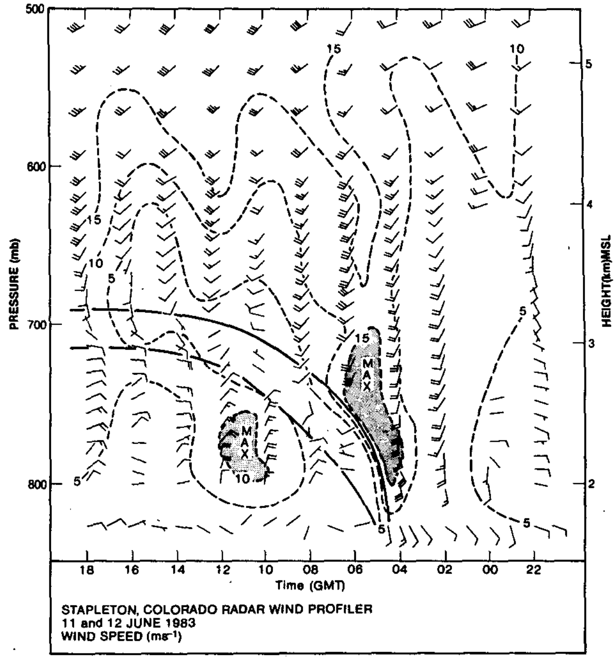

FIG. 7. Surface frontal passage time series analysis of Stapleton, Denver, Colorado, UHF high-vertical resolution (100 m) radar winds between 2200 GMT 11 June and 1800 GMT 12 June 1983. Wind speed (m s^{-1} dashed lines) and frontal boundaries (heavy solid lines). Flags and barbs are the same as those in Fig. 2. Surface winds plotted at lowest height level.

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